ENVIRONMENT AGENCY

South West Region.

Restormel Fish Counter.

Annual Report 2000.

Cornwall Area Ecological Appraisal Team
March 2001

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Executive Summary

The following report presents the daily upstream counts of migratory salmonids recorded on the River Tamar at Gunnislake Weir fish counting station (SX 435 713) situated in 2000.

Data contained within this report covers the period of the commercial migratory salmonid net buy-back scheme and the National Spring Salmon Byelaws. These were in operation on the following dates in 2000:

- Net buy-back - 8 August to 31 August 2000, inclusive
- National Spring Salmon Byelaws – No netting for salmon or sea trout before 1 June.

The fish counter at Gunnislake is a resistivity based system (Logie 2100A – Aquantic limited) and is installed in the fish pass on the Cornish bank of the River Tamar at the head of the tide.

The minimum salmon count for 2000 was 2654. Overall, this indicates that the salmon run in 2000 was 14% higher than that recorded in 1999, over the period April – October. A breakdown of the 2000 salmon run into the two main run components reveals the following:

- A 6% decrease in the numbers of multi sea winter “spring” salmon (March – May) when compared to 1999 figures and a 11% decrease when compared to the 6-year average.

- A 21% increase in the numbers of one sea winter “grilse” (June – August) when compared to 1999 figures and a 3% decrease when compared to the 6-year average.

The 2000 upstream count for sea trout was 6417. This equates to a 49% decrease in the total number of sea trout recorded when compared to the 1999 data (12449) over the period April – October.

The run pattern observed for salmon and sea trout in 2000 was generally consistent with that of previous years. However, the total combined annual count of upstream migrating salmon and sea trout on the River Tamar in 2000 was 18% lower than the 6-year average (1994 – 1999).

The fish counter hut at Gunnislake was flooded on 18/19 December 1999 and again on 30 October 2000. Fish counter data is therefore unavailable from 1 January to 5 April 2000 and 30 October 2000 - 5 January 2001. The counter was recommissioned on the 6 April 2000 and 5 January 2001 respectively. The fish counter has been fully operational and collecting data since 5 January 2001 and further improvements have been put in place to reduce counter downtime due to flooding.

1. Introduction

The following report presents upstream salmon and sea trout counts recorded on the River Tamar at Gunnislake fish counting station (SX 435 713) during 2000. The count data has been considered with respect to:

- daily mean flow (cumecs)
- temperature (°C)
- barometric pressure (mBar)

The flow data reflects the residual flow that exists at Gunnislake weir following abstraction by South West Water (SWW).

The report also includes details of the on-going counter validation work and the annual audit of counter data. This is primarily used to assess counter efficiency and to develop improved methodologies for species apportionment.

2. Background

Fish counters, such as the one installed at Gunnislake Weir, are increasingly becoming essential tools in the management of salmonid fisheries. They provide vital baseline data on the size of the migratory salmonid populations and information on the times during which their migrations occur. This information used in conjunction with other fishery data, such as juvenile survey data and rod / net catches, significantly enhances the formulation of effective management strategies.

The current fish counter at Gunnislake weir is a resistivity-based system (Logie 2100A) manufactured by Aquantic Ltd. The counter was installed in 1992 and validated during 1993 and 1994.

The fish counter at Gunnislake is situated on the River Tamar at the head of the tide and is installed in the fish pass on the Cornish bank of the gauging weir at Gunnislake. The counter operates over a single channel, 1.6 metres in width, via 3 stainless steel electrodes. The electrodes are incorporated into the downstream face of a 'Crump' sectioned weir, which is contained within the fish pass.

The effectiveness of the fish pass was investigated in 1994 / 1995 using radio tracked salmon. The study indicated that 75% of salmon used the Cornish fish pass to migrate up into the freshwater Tamar. The remaining 25% were assumed to have used the Devon bank fish pass or ascended the weir when high spring tides coincided with high water levels – Solomon *et al* (2000).

The counter at Gunnislake is one of two resistivity-based systems operated by the Cornwall Area Fisheries Science Team. The other counter is located on the River Fowey at Restormel Weir (SX 107 613).

A description detailing the operation of the resistivity fish counter at Gunnislake is provided in Appendix 1.

3. Net Buy-Back

National byelaws to protect stocks of 'spring' salmon were introduced on the 15 April 1999. The implementation of these byelaws effectively restricts the salmonid-netting season on the River Tamar from 1 June – 31 August, inclusive.

As in 1997, 1998 and 1999, South West Water (SWW) operated a buy-back of commercial migratory salmonid netting time within the Tamar estuary. In 1998, it switched from 2 March – 7 June to 8 August – 31 August, inclusive. This put a further limit on the times available for netting, effectively restricting the netting season to 1 June – 7 August.

The main aim of the SWW buy-back scheme is to mitigate for the construction of Roadford reservoir and was originally timed to assist in the conservation of multi sea winter fish. It now mainly protects the grilse run.

4. Species Apportionment

The counter has the ability to record electrical changes that are directly proportional to the size of fish that have traversed the counter electrodes. Species apportionment is possible due to the linear relationship that exists between fish length and deflection size (refer to Appendix 4). However, it is not possible to distinguish between a salmon and a sea trout of comparable size. It is therefore inevitable that the salmon count may include some large sea trout. As this situation is most likely to exist between March and the end of June, a data handling protocol has been developed to minimise this eventuality. This is described in Appendix 2.

5. Validation of counter efficiency

Initial validation studies to assess counter efficiency were carried out in 1993 and 1994. The counter was re-validated in 1998 and counter data is now audited, using video footage taken over the weir, on an annual basis. Counter events are matched up with video events, which can then be used to assess the efficiency of the counter and to investigate anomalies in the counter data.

Video validation and the annual audit of counter data is a vital part of the fish counter work at Gunnislake and gives confidence in the accuracy of the data that the fish counter is recording. A complete description of the video validation strategy and methodology is described in Appendix 3.

6. Results

The migratory salmonid counts obtained for the River Tamar recorded at Gunnislake fish counting station in 2000 are presented as follows:

6.1. Upstream Fish Counts

Figure 1: Presents the monthly upstream counts for salmon recorded at Gunnislake weir in 2000 along with the 6-year average. The total number of salmon counted moving upstream in 2000 was 2654 (Table 1).

Figure 2: Presents the monthly upstream counts for sea trout recorded at Gunnislake weir in 2000 along with the 6-year average. The total number of sea trout counted moving upstream in 2000 was 6417 (Table 2).

Figures 3 & 4: Presents the daily upstream counts for salmon and sea trout, in relation to monthly mean flow (cumecs) at Gunnislake weir in 2000.

Figures 5 & 6: Presents the daily upstream counts for salmon and sea trout, in relation to daily mean temperature (^{o}C).

Figures 7 & 8: Presents the daily upstream counts for salmon and sea trout in relation to daily mean barometric pressure (mBar).

Figures 9 – 22: Each of these figures presents daily upstream counts for salmon and sea trout, for each month, in relation to daily mean flow (cumecs) recorded at Gunnislake weir.

Note:

- To aid in interpretation of the data, axis scaling may differ between the monthly summary plots. Care should therefore be taken when interpreting the data within each figure.

- The flow data presented is the residual flow that exists at Gunnislake weir. This has been calculated by subtracting the Daily Mean Abstraction (DMA) from Daily Mean Flow (DMF) data.

Figure 1 – Monthly Upstream Counts for Salmon at Gunnislake Weir 1994 – 2000.

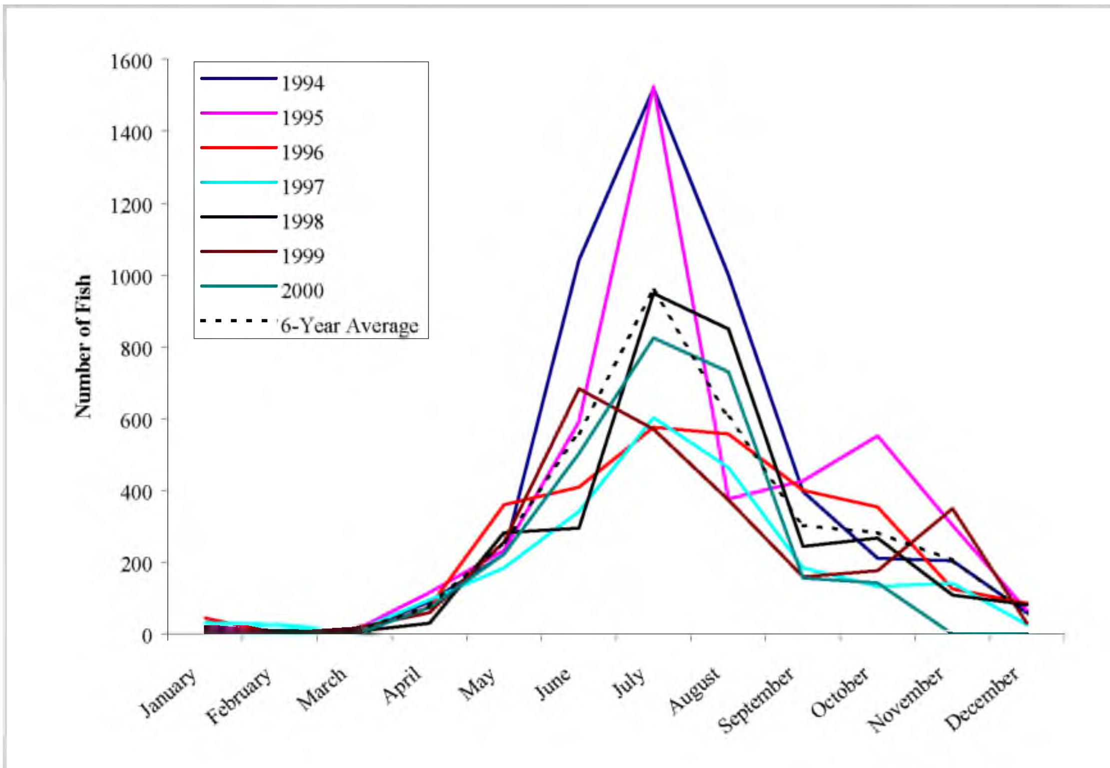


Table 1 - Monthly Upstream Counts for Salmon at Gunnislake Weir 1994 – 2000.

Month	1994	1995	1996	1997	1998	1999	2000	6-yr average
January	15	22	45	32	6	11	*	22
February	3	6	1	27	9	3	*	8
March	6	11	1	8	7	16	*	8
April	90	116	76	95	30	60	74	78
May	222	234	360	185	283	257	223	257
June	1042	591	409	342	295	683	503	560
July	1520	1525	576	603	949	571	825	957
August	1000	376	557	464	850	374	730	604
September	397	427	400	185	244	160	156	302
October	211	552	354	133	268	177	143	283
November	204	303	126	142	109	350	*	206
December	59	65	86	26	82	29	*	58
Totals	4769	4228	2991	2242	3132	2691	2654	3342
Adjusted for 75% fish pass efficiency	6359	5637	3988	2989	4176	3588	3425	

Figure 2– Monthly Upstream Counts for Sea Trout at Gunnislake Weir 1994 – 2000.

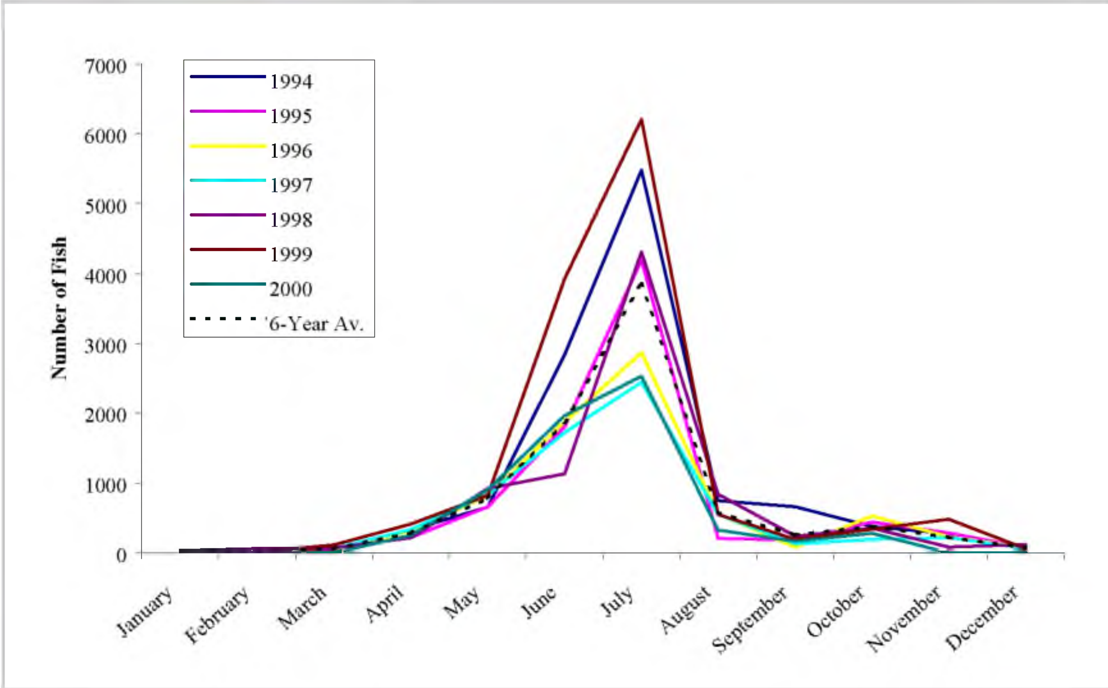


Table 2 - Monthly Upstream Counts for Sea Trout at Gunnislake Weir 1994 – 2000.

Month	1994	1995	1996	1997	1998	1999	2000	6-yr average
January	32	17	51	22	34	28	*	31
February	2	12	8	62	59	11	*	29
March	55	59	49	65	71	116	*	60
April	329	221	313	333	217	411	254	283
May	653	659	817	835	921	826	901	777
June	2841	1807	1875	1724	1131	3927	1964	1876
July	5478	4190	2868	2440	4311	6207	2530	3857
August	748	206	556	548	838	549	326	579
September	661	181	78	127	237	191	163	257
October	377	438	529	194	354	338	279	378
November	275	284	230	220	82	482	*	218
December	51	78	78	62	120	59	*	78
Totals	11502	8152	7452	6632	8375	13145	6417	8423
Adjusted for 75% fish pass efficiency	15336	10869	9936	8843	11167	17527	8556	

Figure 3 – Daily Upstream Counts of Salmon in Relation to Flow (cumecs) at Gunnislake Weir 2000.

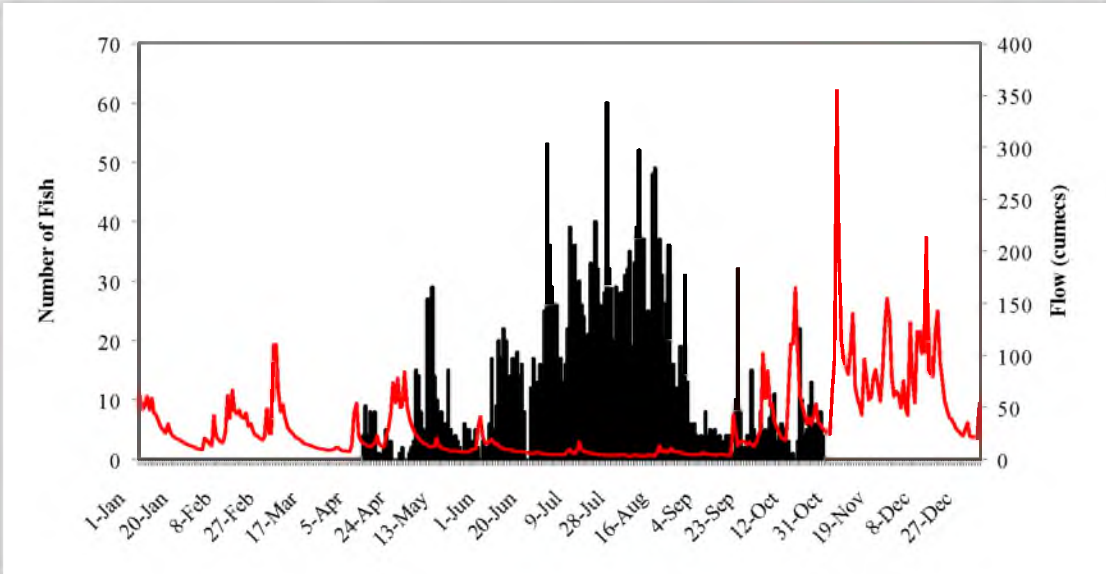


Figure 4 – Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Gunnislake Weir 2000.

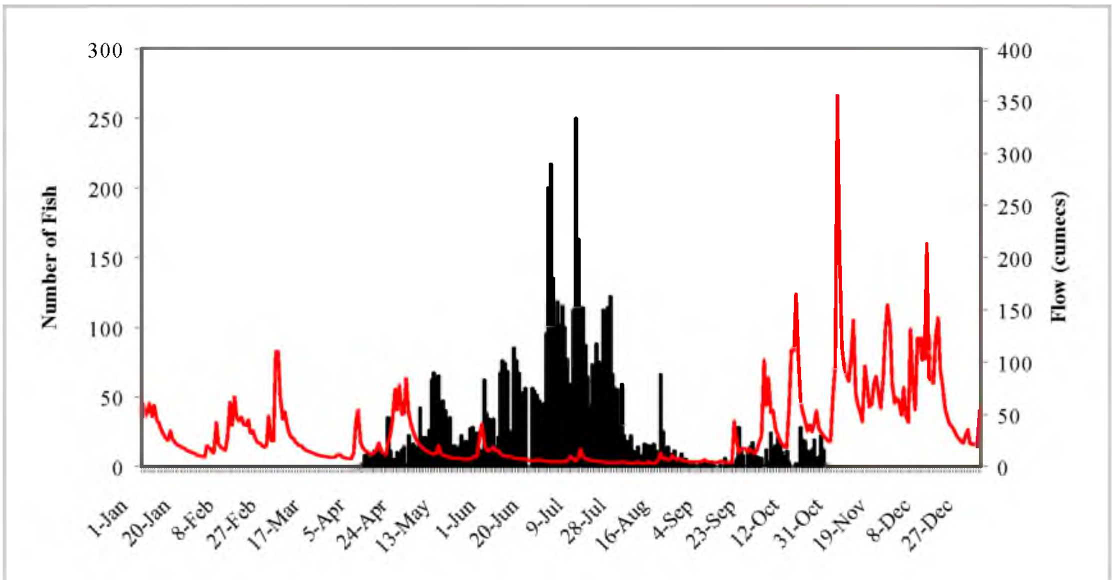


Figure 5 - Daily Upstream Counts of Salmon in Relation to Temperature (^{o}C) at Gunnislake Weir 2000.

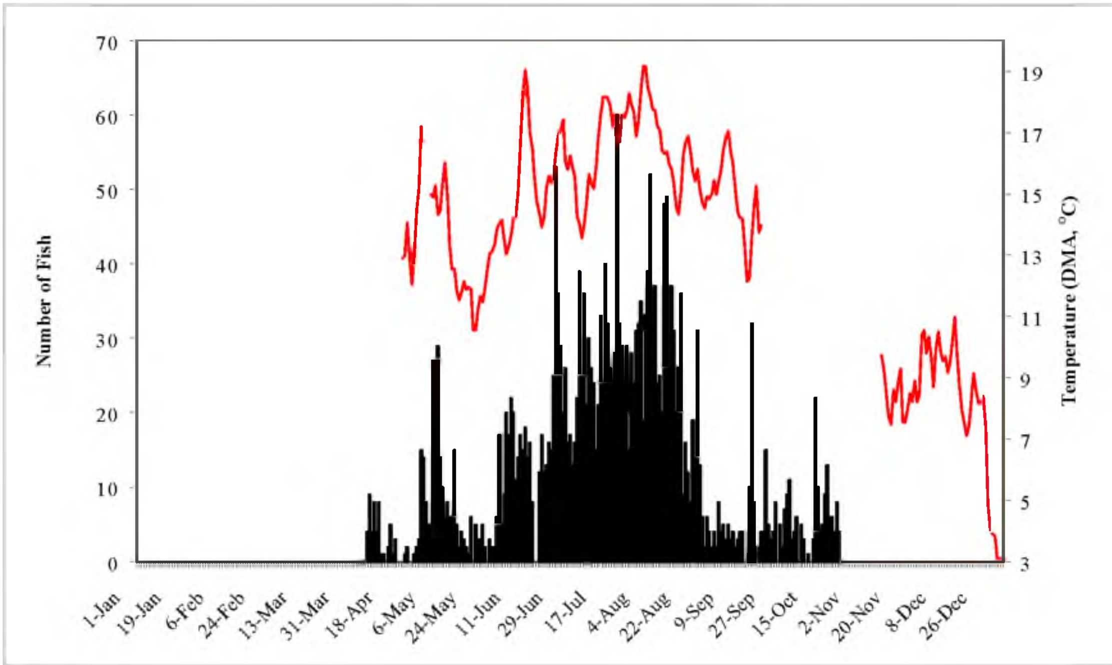


Figure 6 - Daily Upstream Counts of Sea Trout in Relation to Temperature (^{o}C) at Gunnislake Weir 2000.

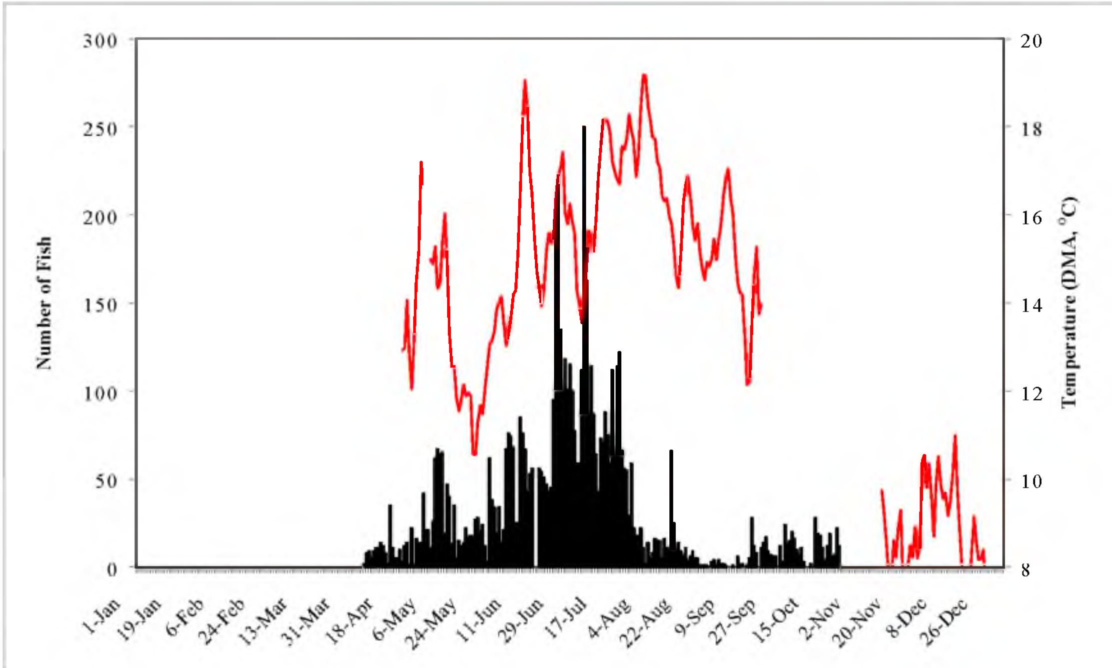


Figure 7 - Daily Upstream Counts of Salmon in Relation to Changes in Barometric Pressure (mBar) at Gunnislake Weir 2000.

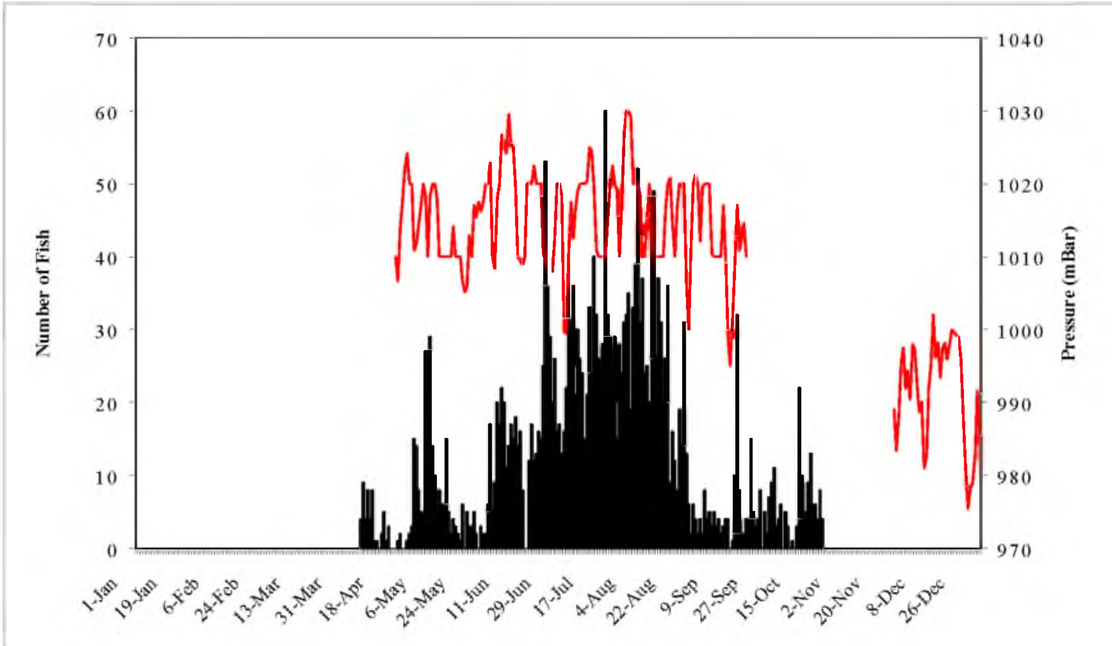


Figure 8 - Daily Upstream Counts of Sea Trout in Relation to Changes in Barometric Pressure (mBar) at Gunnislake Weir 2000.

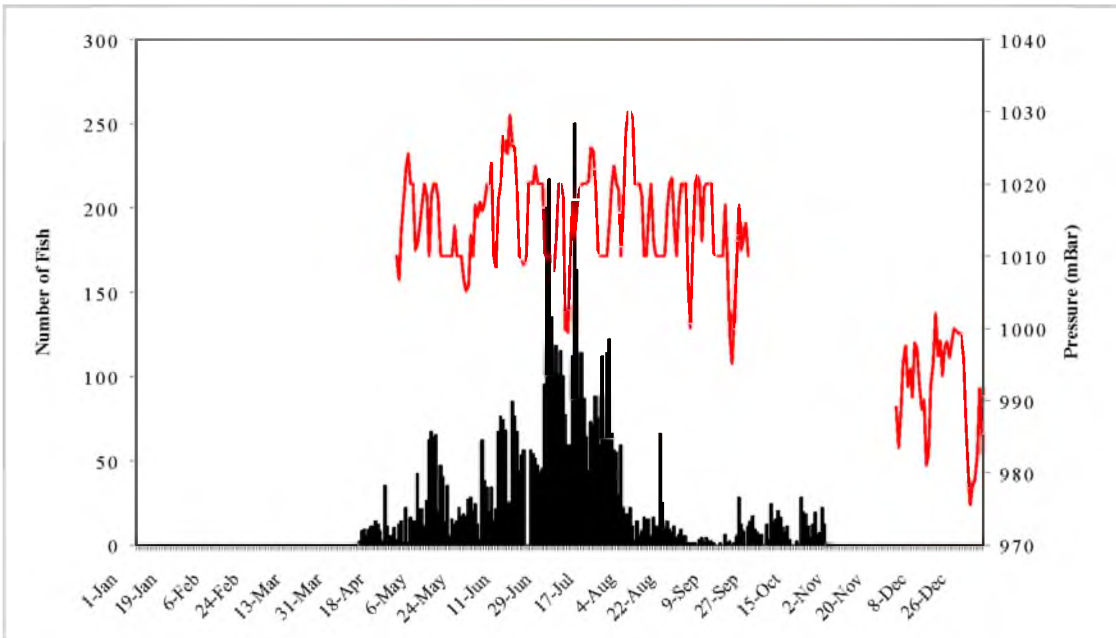


Figure 9 - Daily Upstream Counts of Salmon in Relation to Flow (cumecs) at Gunnislake Weir – April 2000.

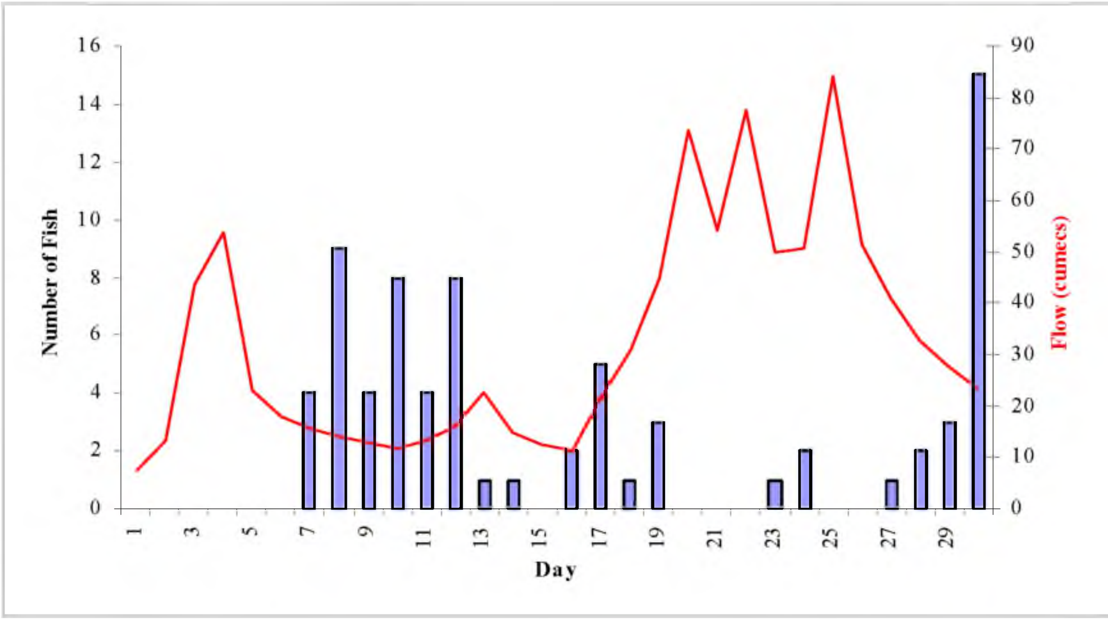


Figure 10 - Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Gunnislake Weir – April 2000.

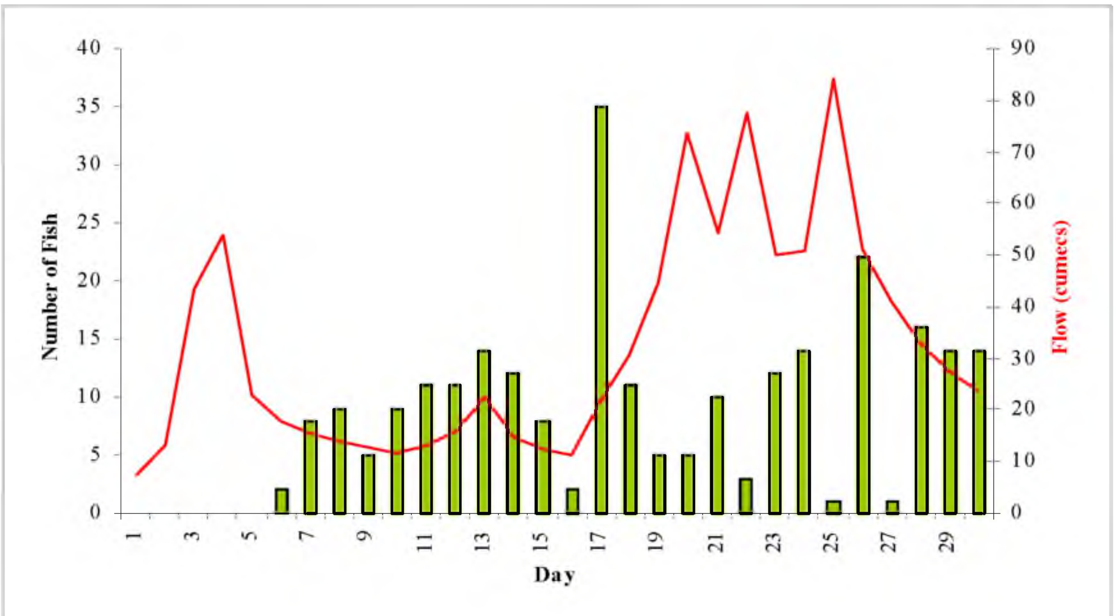


Figure 11 - Daily Upstream Counts of Salmon in Relation to Flow (cumecs) at Gunnislake Weir – May 2000.

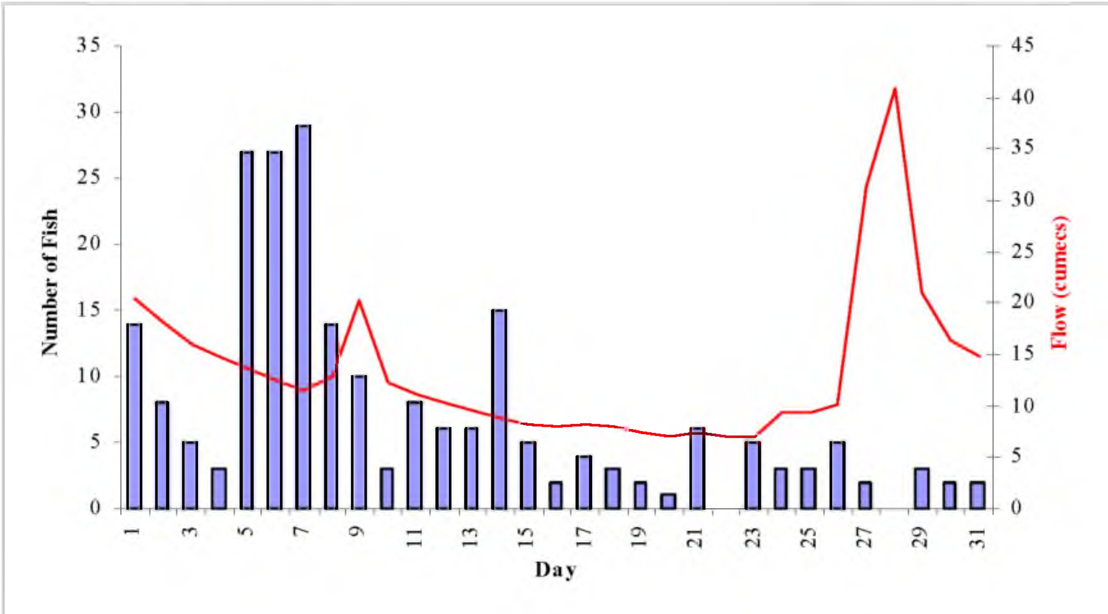


Figure 12 - Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Gunnislake Weir – May 2000.

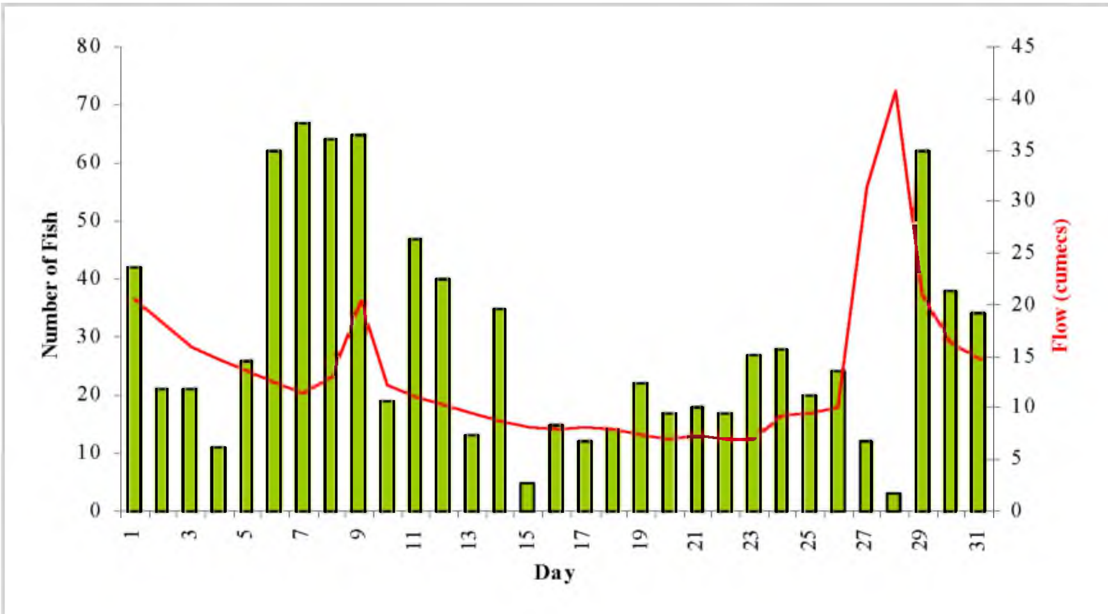


Figure 13 - Daily Upstream Counts of Salmon in Relation to Flow (cumecs) at Gunnislake Weir – June 2000.

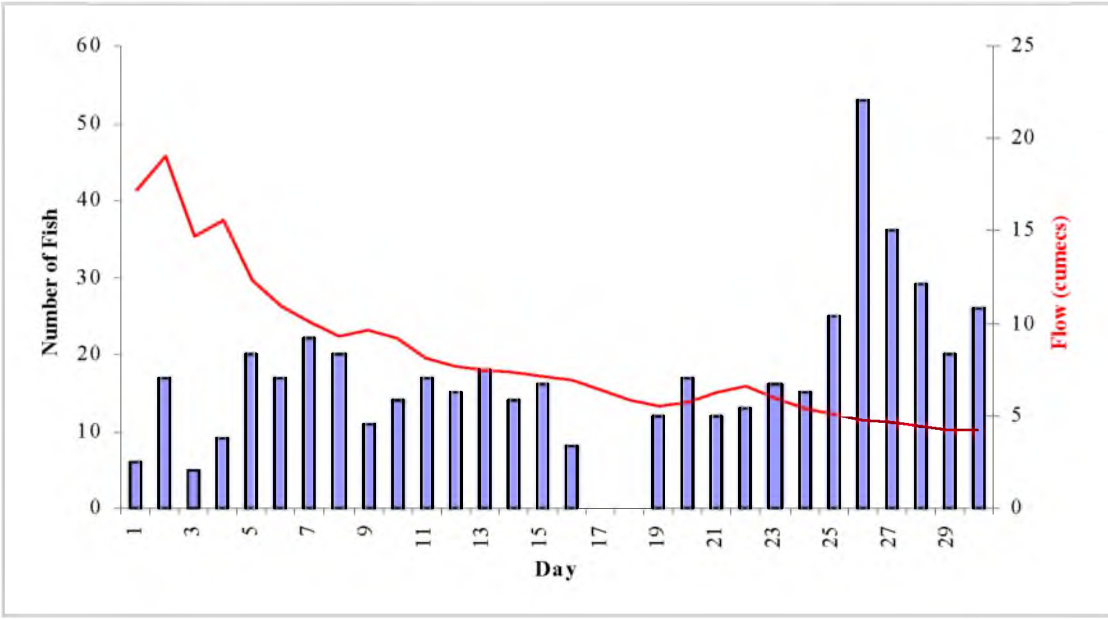


Figure 14 - Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Gunnislake Weir – June 2000.

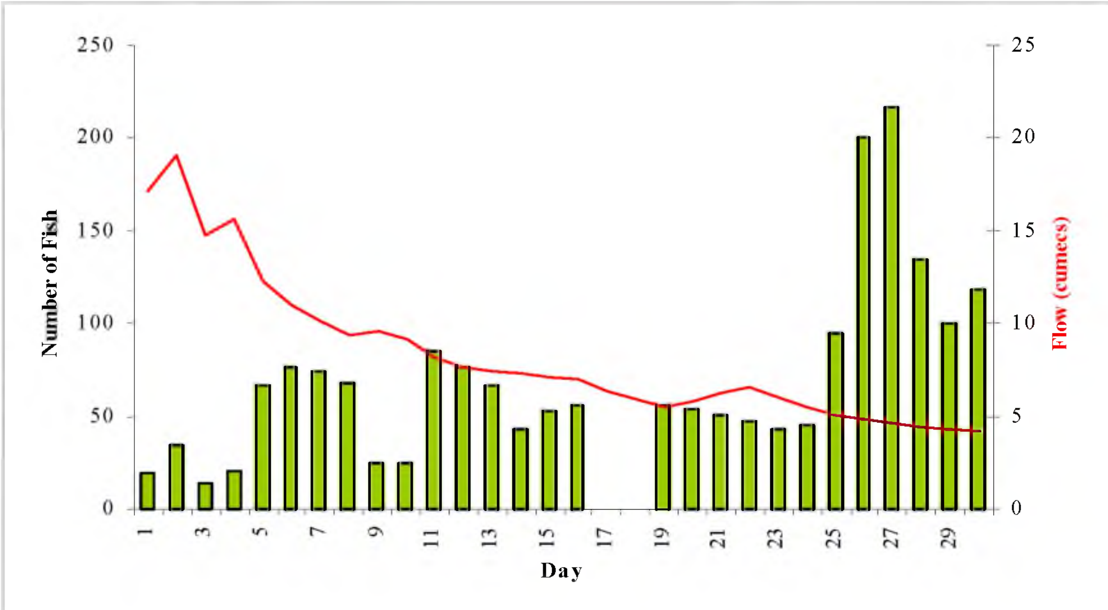


Figure 15 - Daily Upstream Counts of Salmon in Relation to Flow (cumecs) at Gunnislake Weir – July 2000.

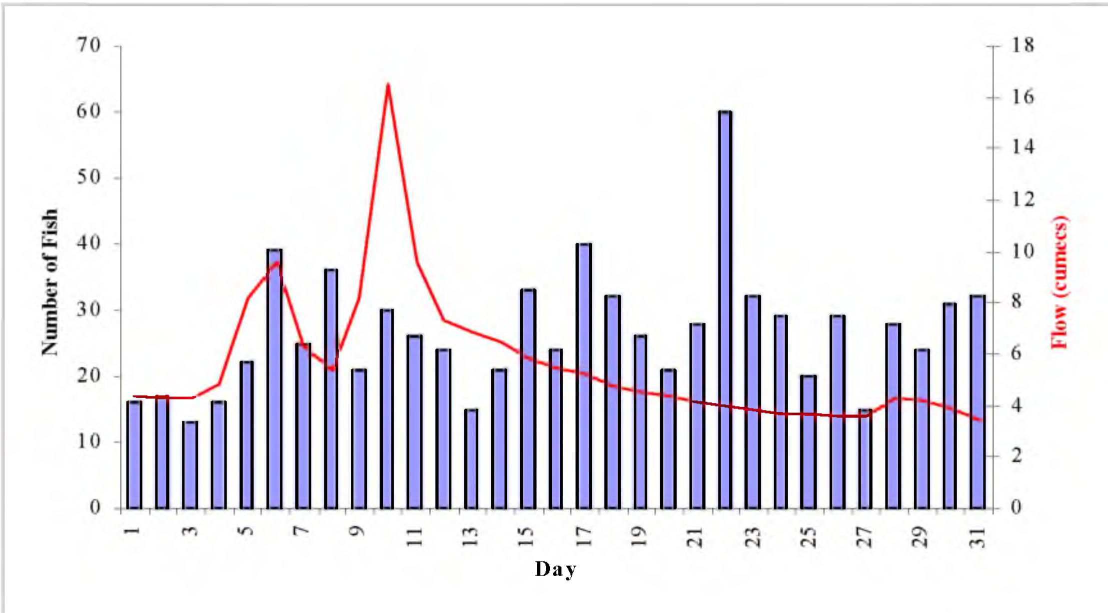


Figure 16 - Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Gunnislake Weir – July 2000.

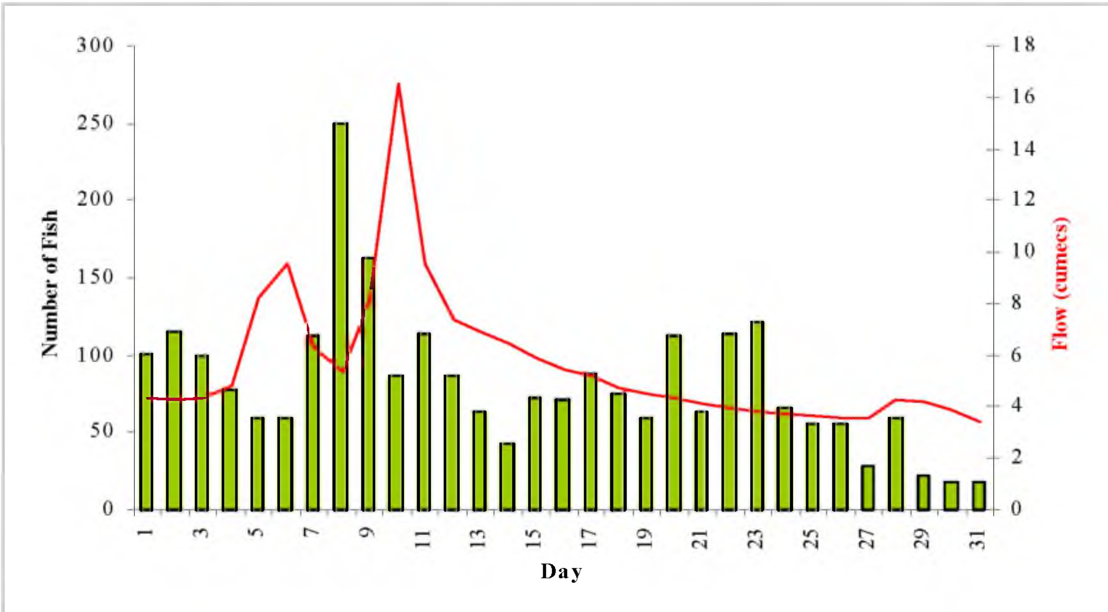


Figure 17 - Daily Upstream Counts of Salmon in Relation to Flow (cumecs) at Gunnislake Weir – August 2000.

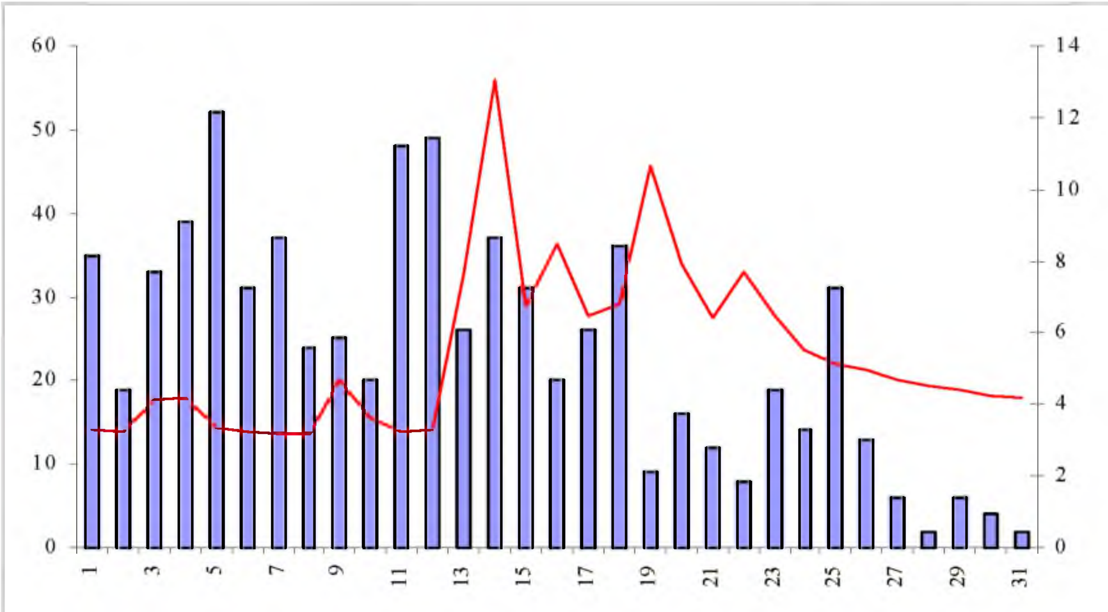


Figure 18 - Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Gunnislake Weir – August 2000.

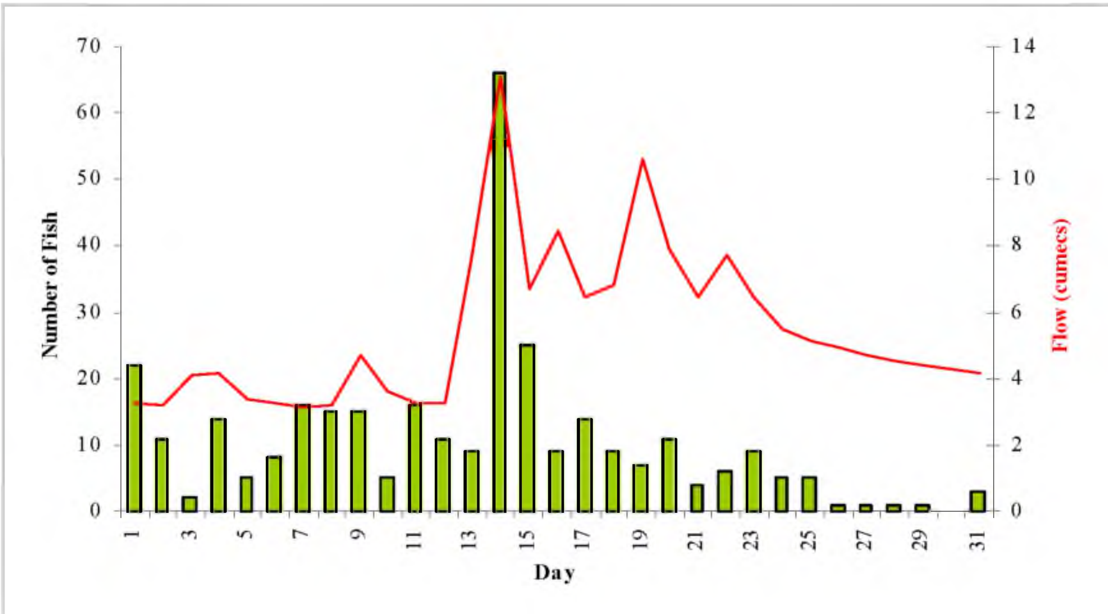


Figure 19 - Daily Upstream Counts of Salmon in Relation to Flow (cumecs) at Gunnislake Weir – September 2000.

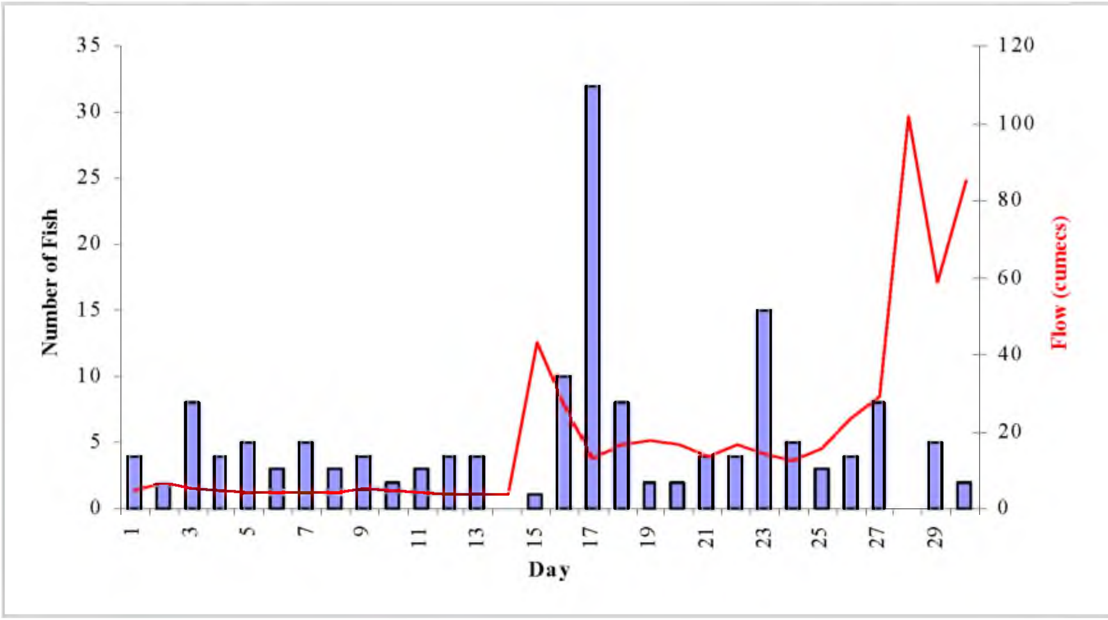


Figure 20 - Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Gunnislake Weir – September 2000.

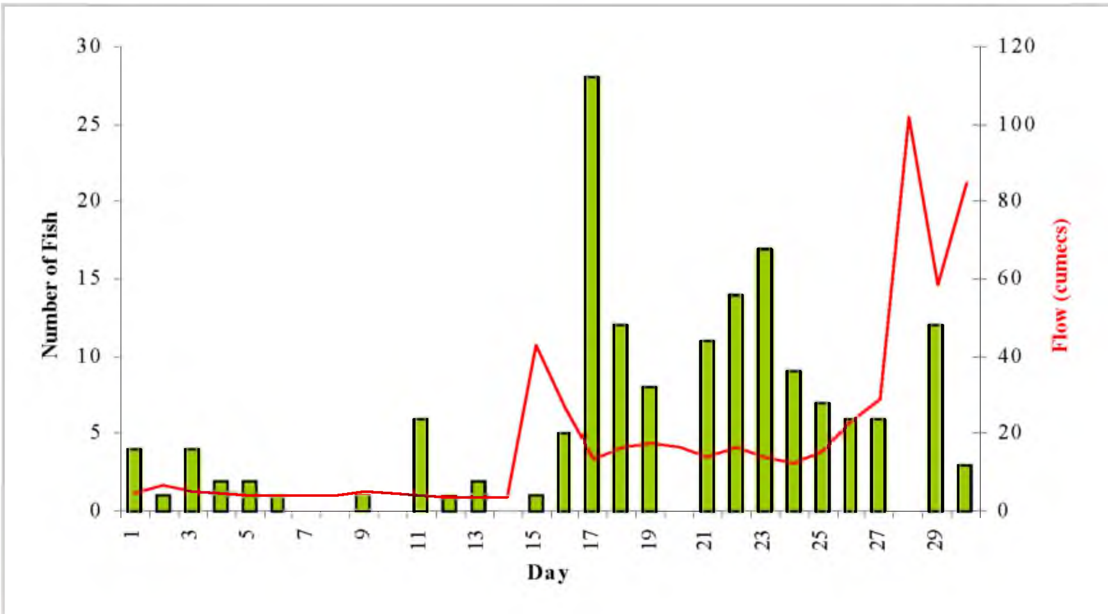


Figure 21 - Daily Upstream Counts of Salmon in Relation to Flow (cumecs) at Gunnislake Weir – October 2000.

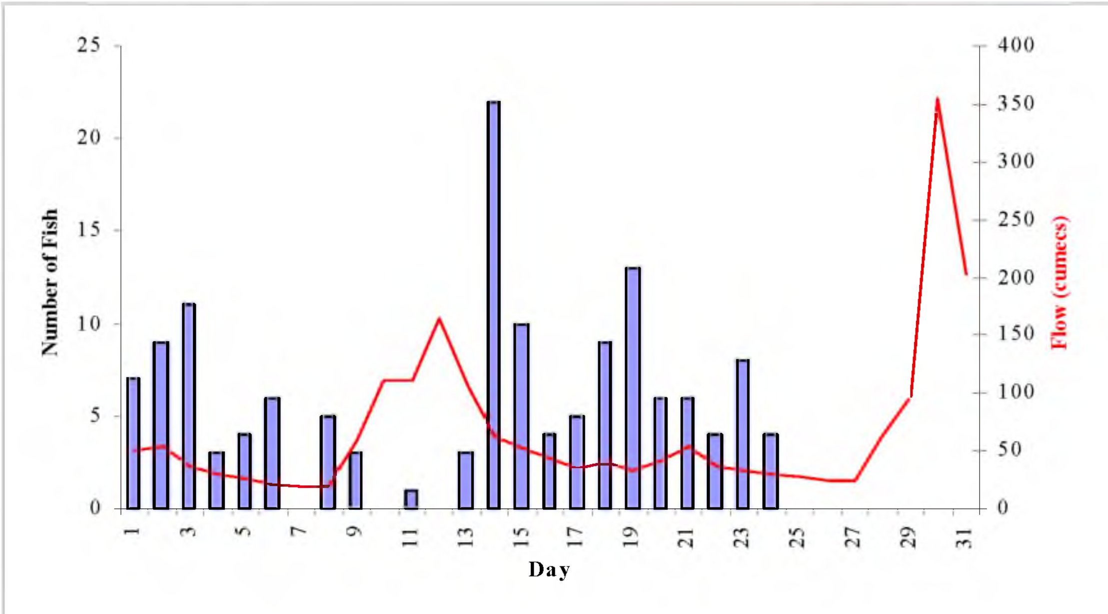
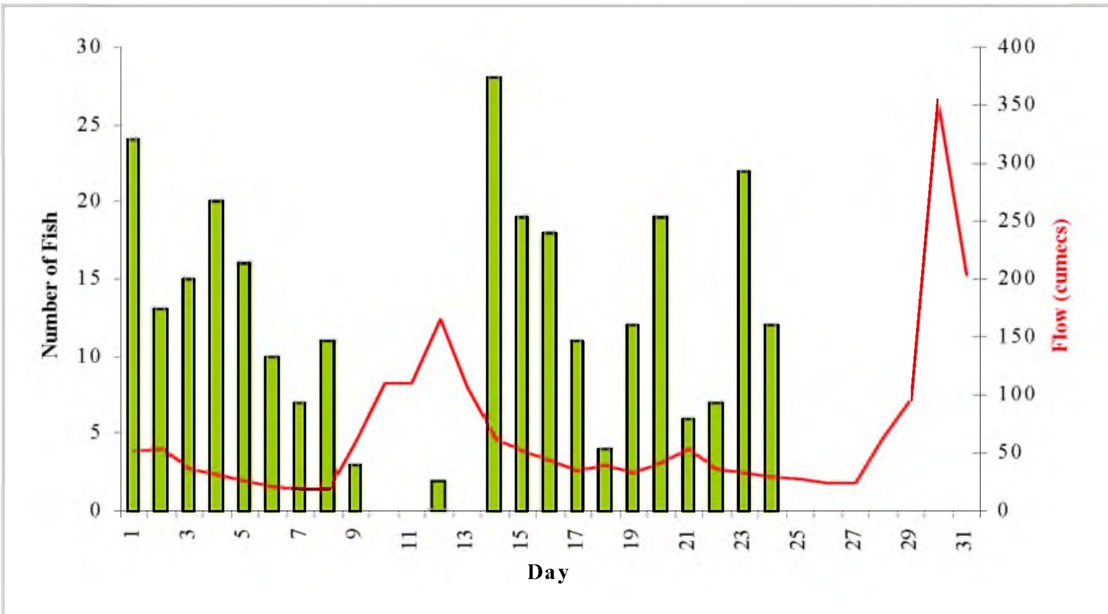


Figure 22 - Daily Upstream Counts of Sea Trout in Relation to Flow (cumecs) at Gunnislake Weir – October 2000.



6.1 Video Validation & Counter Efficiency

6.1.1 Counter Efficiency

Table 3 – Analysis of video validation data for Gunnislake fish counter over the period June – July 2000

Item	Counter	Video	Detection Efficiency (%)
Total No of 'Events'	486	590	82
Missed events	77	1	x
Failed attempts detected	0	27	x
Corrected counts	486	562	**86**
Total Upstream Salmonid Counts	327	404	**81**

The overall detection efficiency for upstream salmonids in June and July was 81%. The detection efficiency was calculated using data for upstream migrating salmonids detected by the counter or seen on video. Non-target species (lamprey etc) or spurious events (82) were removed from the data prior to this analysis.

6.1.2 Size Correction Factors

Table 4 utilises matched counter and video data for upstream migrating salmonids to calculate count correction factors for the period June – July 2000. All non-target species i.e. non-salmonids, have been removed for the purposes of this calculation.

Table 4 – Size correction factors for salmonid counts recorded at Gunnislake fish counter over the period June – July 2000

Item	Counter	Video	Correction Factor
Upstream Counts >50	82	72	0.88
Upstream Counts <50	200	210	1.05
Total	282	282	

7. Discussion

The 6-Year average plotted in Figures 1 and 2 indicate that the seasonal run patterns observed for salmon and sea trout on the River Tamar in 2000 were consistent with previous years.

There was a 38% decrease in the total combined annual count for upstream migrating salmonids on the River Tamar in 2000 (9071) when compared to 1999 (14731) over the same period. Comparisons with the 6-year average (11048) also indicate that the total combined count for salmonids in 2000 has decreased by 18%.

Data was lost from 1 January – 5 April 2000 and 30 October - 5 January 2001 due to flooding. The unusual nature of the conditions means that any attempts to estimate the numbers of fish moving during this period are likely to be inaccurate. In light of this any comparative analysis between years has been made on data from April – October for **all years.**

7.1. Salmon counts recorded on the River Tamar 1995 - 2000

The minimum salmon count estimate for 2000 was 2654. Overall, the salmon run estimate for 2000 was 14% higher than in 1999 (2282) but was the third lowest count on record over the period April – October. The lowest overall figure was recorded in 1997 (2007).

The salmon run on the River Tamar, as with many of the other rivers in the South West, usually begins in April / May and continues until the end of November / beginning of December. The larger multi sea winter or ‘spring’ salmon are generally the first component of the salmon run to be seen (March – June), followed by the higher numbers of smaller one-sea winter fish, grilse. The grilse component of the stock is most prevalent in the period June - August.

The salmon counts for 2000 are down on the 6-year average for all months except August, in the period April – October, and 13% down on the 6-year average.

The salmon data has been split down into its two major components. The split has been made on the basis of size and using historical trap, net and rod catch data (Appendix 4). The breakdown of the 2000 salmon run data into its two main run components is as follows:

- Count figures indicate that the 297 multi-sea winter “spring” salmon counted between April – May 2000 represented a 6% decrease in the size of this component of the salmon run, in comparison to figures for 1999. Comparisons to the 6-year average (335) for the same period shows that there has been an overall drop of 11% in the size of the multi-sea winter ‘spring’ salmon component of the salmon run.

- The counter data indicates that the 2058 grilse counted between June – August 2000 represents a 21% increase in the grilse component of the total salmon run estimate, when compared to 1999 figures (1628). Comparing this to the 6-year average (2121) over the same period implies that there has been a 3% reduction in the size of this component of the salmon run.

The slight decrease in the multi-sea winter ‘spring’ component of the run is a little discouraging; the count (297) is the second lowest count for this period over the past 6 years. Comparisons with the 6-year average indicate that, overall; the numbers of these ‘spring’ fish are still declining.

Conversely, for grilse, 2000 was a good year. The minimum count estimate for the period June to August (2121) is the third highest figure recorded over the past 6 years. The significant increase in the size of grilse component of the 2000 run in comparison with the 6-year average is encouraging and may indicate the success of net buy back and netting restrictions which, although originally put in place to protect ‘spring’ salmon, now largely protects the grilse run.

7.2. Sea Trout Counts Recorded on the River Tamar 1995 - 2000

The main sea trout run on the River Tamar has historically been consistent with that of many other rivers in the South West and is concentrated predominantly in the months of June and July.

Traditionally, the sea trout run begins in May with the peak movement, predominantly ‘school peal’, taking place in June and July. Smaller runs occur in April, May and August with numbers declining sharply near the end of August with only small numbers moving upstream thereafter.

The counter data indicates that 2000 was not an exceptional year for sea trout (6417). The minimum run estimate for 2000 represents a 49% decrease when compared to the 1999 estimate (12449) over the same period and is the second smallest count recorded over the 6 years of counter operation. The lowest count that has been recorded over the period was in 1997 (6201).

The majority of the run was concentrated in June and July and, although the pattern of the run is similar between years, the numbers of fish moving are below the 6-year monthly average (Figure 2).

Through the use of historical net, trap and rod catch data an attempt has been made to split the sea trout run into its two major components, namely the larger repeat spawners and the smaller ‘school peal’. The initial split between salmon and sea trout has already been provided through the use of deflection sizes. It is hoped that this splitting of the sea trout data may provide a clearer indication on the state of each portion of the sea trout stock.

The assumptions made for this split are that the majority of larger repeat spawners are concentrated in the months April to May and ‘school peal’ in the period June – August.

A breakdown of the 2000 sea trout run data into its two main run components is as follows:

- Count figures indicate that repeat spawners counted between April – May 2000 (1155) represented a 7% decrease in the size of this component in comparison to figures for 1999 (1237). However, comparisons to the 6-year average (1089) for the same period shows that there has been an overall increase of 6% in the size of this component of the sea trout run.

- Counter data indicates that the 4820 school peal counted between June – August 2000 represents a 55% decrease in this component of the total sea trout run estimate, when compared to 1999 figures (10683). Comparing this to the 6-year average (7041) over the same period shows that there has been a 32% reduction in the size of this component of the salmon run.

The slight increase in the repeat spawner component of the run when compared to the 6-year average is probably to be expected due to the net buy-backs and netting restrictions operated in recent years. This will have allowed many more of these larger multiple spawners to 'escape' into the freshwater Tamar via Gunnislake fish pass.

7.3. Other Species

As in 1998 and 1999 there were large runs of sea lamprey (*Petromyzon marinus, L*) in May, June and the beginning of July (>180), and six upstream migrating shad (*Alosa sp.*) were detected by the surface skimming camera over the period June - August. The majority of these events were identified from counter data and video footage, the counts were adjusted accordingly to remove these species from the salmonid count.

7.4 Environmental Factors

Environmental variables routinely measured at Gunnislake are flow, temperature, barometric pressure and conductivity. Rate of flow is generally considered to be the dominant factor controlling the upstream migration rate of salmonids. However it should not be considered in isolation as its effects are often modified by other factors such as water temperature, changes in barometric pressure; together with wind, weather and tide conditions etc.

7.4.1. Flows on the River Tamar 1995 - 2000

The patterns of flow recorded at Gunnislake in 2000 during the period of the main fish runs were generally consistent with that of previous years. The majority of upstream migrating salmonids tended to utilise flows between 3 – 20 cumecs over the period of available counter data, which again is consistent with data for previous years.

The period January to April showed a slight elevation in flows but the period November to December showed an abnormal increase in both the level and duration of high flows when compared to 1999.

Analysis of the count figures for 1999 indicated that only a small percentage (1%) out of the total number of fish recorded moved over the weir when daily mean flows were in excess of 40 cumecs (179 fish out of a total of 15836). Flow conditions in excess of 40 cumecs were present for 14% of the year in 1999. 40 cumecs was then used as the cut off point to assess the numbers of fish that could potentially have moved during the period when the counter was out of operation in 2000 i.e. during periods of high flow.

In 2000 flows in excess of 40 cumecs were present for 28% of the time. Of these flows 70% were concentrated in the periods 1 January – 6 April and 1 November – 31 December 2000. This suggests that few fish were likely to be moving when the fish counter was not operational.

7.4.2. Water Temperature

Figures 5 & 6 indicate that the patterns of fish movement coincide with rises and falls in temperature over the period 6 April – 30 October. Although the evidence for the influence of temperature on upstream migration is inconclusive (Banks, 1969) it is generally accepted that salmonids tend to move within an optimum temperature band of between 5°C – 21.5°C (Alabaster, 1970). Bearing this is mind the patterns of fish movement with regards to temperature are probably to be expected. However the temperature data is still of interest as part of a long term data set as the energetic costs of migrations outside of this optimum band may, in part, account for the timing of river entry and the subsequent behaviour displayed by the migrating fish (Milner, 1989). With the current interest in climate change temperature data may therefore provide early evidence on the effects of global warming on migratory fish populations and in particular changes in the timing of their migrations.

7.4.3. Barometric Pressure

Figures 7 & 8 indicate that the relationship between barometric pressure and fish movements is not as clear as that existing for temperature and flow. It is also not clear to see from the data whether fish are moving prior to an increase in flow i.e. using a drop in pressure to predict an increase in flow. The data, as might be expected, shows a small degree of correlation between flow and barometric pressure. This is particularly evident in the period from the end of November to the end of December where changes in flow and barometric pressure mirror each other almost exactly.

Changes in barometric pressure have often been thought to a play a part in stimulating the upstream movements of salmonids. However evidence in the scientific literature is inconclusive and often contradictory. Banks (1969) conducted a thorough literature review of the factors affecting the upstream migrations of salmonids and concluded that although temperature had a significant effect on salmonid migrations the effect of changes in barometric pressure were minimal. However, anecdotal evidence seems to suggest that changes in barometric pressure may affect fish movements to a greater degree, once the fish are within the river system, and it is therefore worthy of further investigation.

Summary

The increase in grilse numbers could be due to one or a combination of favourable factors. The introduction of net buy-back schemes over the past few years will undoubtedly have allowed a greater proportion of these fish to enter the freshwater

Tamar. The same situation does not seem to be true for multi sea winter fish and may be the result of poor survival rates or high exploitation \ predation at sea.

The decrease in the numbers of returning sea trout, especially in comparison to 1999 figures, are again likely to be due to poor survival rates and / or exploitation etc although it may also be due to a natural 'boom-bust' cycle within the sea trout population. The exceptional run of sea trout last year will also have inflated the 6-year average. If the figures for 1999 are omitted i.e. average calculated 1994 – 1998, figures actually suggest a 9% increase in the numbers of repeat spawners, compared to the historical average.

It is unlikely that a reliable estimate for the periods when the counter was out of action can be made. Counts recorded prior to the counter being out of action, together with data from previous years and the nature of the prevailing conditions suggests that the numbers of fish traversing the weir are likely to be relatively low and would therefore have little effect on the overall run patterns.

The environmental data indicates that flow is the overriding factor affecting fish movement. The effect of changes in temperature and barometric pressure on fish migration is still a unclear but temperature, in particular does seem to be linked to the timing of fish migration into the river.

7.5. Video Validation and Counter Efficiency

The new infra red lighting system that was installed at Gunnislake allowed footage to be taken during the night. 2100hrs – 0700hrs was shown to be the optimum period for fish movements so the majority of footage was collected over this timescale.

The counter efficiencies for upstream migrating fish are comparable with those found in the validation study in 1993 i.e. around 90%. Losses in efficiency can largely be attributed to groups of sea trout passing over the weir in groups of two or more.

Table 5 – Summary of Video Validation at Gunnislake Fish Counter 2000.

Camera	No. of Hrs. Recorded	Period of Operation	No. of Hrs. Watched
Downward Facing Camera	918.48	11/4 - 3/9	367.39 **(159.63)**
Surface Skimming Cameras	798.75	5/5 - 3/9	415.35

(Figure in brackets is the number of hours used to calculate efficiencies as accurate fish length measurements were taken during this period).

The counter efficiencies (Table 3) are based on the number of fish that have been seen on video and recorded by the counter, predominantly during the hours of darkness, over the period (11/4/00 – 3/9/00).

The overall detection efficiency of the counter for upstream migrating fish was estimated at 81%. This level of efficiency is comparable to that found in the initial validation study conducted in 1993 (90%). Slight losses in efficiency can be attributed to the large numbers of sea trout passing over the weir in groups of two or more. In many cases these were recorded as single fish counts or as “non-fish” events, which resulted in a slight under estimate for sea trout.

The correction factors that were calculated in Table 4 indicate that the counter is slightly over-estimating the numbers of salmon (+6%) and is under-estimating the numbers of sea trout (-3%). This is due to the high numbers of fish moving over the weir, especially in groups, over this period. Groups of fish crossing the electrodes may return deflection values >50 which could then boost the apparent numbers of salmon according to the fish counter. Video evidence allows us to correct for these events. Even so, this is only likely to happen during this period and has little effect on the figures for the run estimates. However the information can be used to fine tune the gain settings of the fish counter, to improve the sizing capability of the fish counter, and thereby improve species apportionment during these periods.

8. Data Processing

The data presented in this report represents final adjusted counts, which takes into account maintenance work on the fish pass and non-target species etc. Weir cleaning was initiated in May 1998. Data from 1998 and from previous years was not affected by this activity.

The original monthly summary reports distributed in 2000 were intended to give a general indication of salmonid movements and to provide an estimated minimum salmonid count for each month. Any data contained within the original monthly summary reports has been superseded by this report.

9. Update

- The Gunnislake site has suffered from a loss of counter data on two occasions during 2000 due to flooding. Two unusual flood events occurred, 18/19 December 1999 and 30 October 2000, which affected both the electrical systems and the fish counter at Gunnislake. Subsequent flooding from November onwards hampered repair work, which led to the delays in recommissioning. The Agency is now investigating relocation options for the hut within the Gunnislake site to prevent further flooding problems. In the interim the hut and equipment has been waterproofed as much as possible to reduce flood damage to a minimum.

- New high power infra red lights were installed 24 May 2000 and have allowed us to collect good quality night time footage.

- The surface-skimming camera was again deployed and shows great promise as an aid to accurate species identification and for the identification of fin clipped fish.

10. Future Work

- Continued validation of the counter's performance and efficiency will be carried out on an annual basis using side aspect and overhead video cameras.

- To assess the presence and abundance of non-target species traversing the fish pass e.g. Shad (*Alosa sp.*), Sea Lamprey (*Petromyzon marinus*) and Mullet (*Mugil sp.*).

- Identification of adipose fin-clipped salmon tagged as part of the continuing CEFAS smolt-tagging programme that is being undertaken on the River Tamar. This study has been undertaken to assess marine survival and, in particular, exploitation within the Irish drift net fishery.

- Installation of a TRACKER data-logging / counter interrogation unit. The units will be used to telemeter both trace and counter data via a modem link and are a partial replacement for the laptop computers currently used. The units will help to standardise fish counter data collection / validation methods and bring the Gunnislake site into line with other Environment Agency regions.

- As in 2000, an experimental surface skimming camera will be installed in time for the main run of fish in 2000. The camera was installed at the beginning of August in 1999; primarily to identify fin clipped fish as part of a smolt-tagging project, in collaboration with CEFAS. The preliminary analysis of the video data from 1999 and 2000 was encouraging and shows that the camera is good for accurate species identification. Results also suggest that the camera can be used in conjunction with counter, net, rod and historic trapping data to improve species apportionment and it has already been used to identify both upstream and downstream migrating shad (*Alosa sp.*)

- Collection of temperature and barometric pressure at hourly intervals via two sensors / data-loggers will be continued in 2001. These have been installed to investigate the effects of changes in temperature and pressure on the movements of salmonids. These will provide valuable additional data, which can be used in conjunction with the counter, flow and video data to improve our knowledge of salmonid movements on the River Tamar.

- Use of fish counter data to improve information on flows required for species specific upstream migrations i.e. salmon, sea trout etc. Information from radio tracking studies have already been used to calculate migration indices for salmon at Gunnislake Weir but fish counter information could provide more detailed information over a wider range of conditions, for a larger sample size and for a range of species.

- Installation of a Hard Disk Video Recorder (HDD VCR), which can be programmed to capture images of fish passing over the weir only when a fish passage event is occurring i.e. triggered by the fish counter. If successful, this will dramatically reduce video-watching times, as footage will only be collected when an event is occurring. The video will run in parallel with a conventional time-lapse video, which will act as an audit for the HDD VCR video data.

- As part of the index river study the trap at Gunnislake will be operating in 2001. The data from the trapping study will provide valuable information on the different components of the migratory salmonid runs on the River Tamar. It will also provide data on non-target species such as Shad (*Alosa sp.*) and Sea Lamprey (*Petromyzon sp.*).

11.Downtime

The counter was operational for 7350 hours out of a possible 8760, approximately equivalent to 306 days out of a total of 365 days. The majority of this downtime can be attributed to the counter being out of operation due to flooding. The downtime has been broken down as follows:

Table 6 – Breakdown of Counter Downtime in 2000.

Item	Downtime		Sub-Total	% Downtime	
	Enforced	Routine		Enforced	Routine
1. Weir cleaning (gate shut)	1.5	2.42	3.92	0.11	9.81
2. Counter Maintenance	0	0.00	0.00	0.00	0.00
3. Camera Maintenance	0	5.42	5.42	0.00	21.97
4. Counter Fault	0.00	0.00	0.00	0.00	0.00
5. Other	1392.67	16.83	1409.50	99.89	68.22
Total Downtime (Hours)	1394.17	24.67	**1409.50**		
Expected Operational Hours	8760.00				
% Time Operational	83.91				

12. References

01. Environment Agency (1997). Design and Use of Open Channel Resistivity Fish Counters (Advisory Manual). Fisheries Technical Manual No. 2. Environment Agency North West Region. R&D Technical Report W23.

02. Environment Agency (1997). Salmon and Sea Trout Movements Recorded at Gunnislake Fish Counting Station on the River Tamar during 1996. Environment Agency. Annual Report 1997.

03. Environment Agency (1998). "A Preliminary Assessment of the Buy-back of licensed Migratory Salmonid Netting Time on the River Tamar in 1997 and 1998. Environment Agency. Gunnislake Fish Counter Data Report - July 1998.

04. Solomon, D.J, Sambrook, H.T, Broad, K.J (2000). Salmon Migration and River Flow: "Results of Tracking Radio Tagged Salmon in Six Rivers in South West England." Research & Development Publication 4. Environment Agency 2000.

05. Environment Agency (1998). Gunnislake Fish Counter. Annual Report 1998. Environment Agency 2000.

06. Environment Agency (1999). Gunnislake Fish Counter. Annual Report 1999. Environment Agency 2000.

07. Banks,J.W. (1969). A review of the literature on the upstream migration of adult salmonids. J. Fish Biol. 1, 85-136.

08. Milner, N. J. (1989). Fish movement in relation to freshwater flow and quality. Workshop proceedings of The Atlantic Salmon Trust 6 April 1989.

09. Alabaster, J.S. (1970). River flow and upstream movement and catch of migratory salmonids. J. Fish. Biol. 2, 1-13.

13. Appendices

Appendix 1 - Operating protocol for the Logie 2100A resistivity fish counter at Gunnislake Weir.

To detect fish passing upstream, the Logie 2100A utilises three stainless steel electrodes that are set into the downstream face of the fish pass at Gunnislake Weir. The construction of the fish pass ensures a smooth laminar flow of water over the electrodes and allows the fish to ascend the weir in close proximity to the electrode array. The electrodes are set into 'Nitomortar' (low conductivity cement) to reduce fluctuations in resistivity due to the structure and between the electrodes.

The counter operates by applying a low positive/negative voltage (5 volts) at high frequency to the upper (+5 volts) and lower (-5 volts) electrodes. The net voltage at the central electrode is virtually zero as the two voltages effectively cancel each other out. As a fish passes over the bottom electrode it acts as a weak electrical conductor, causing an increase in the negative voltage at the central electrode. As a fish passes over the central and upper electrode it causes an increased positive voltage at the central electrode. The net result of a fish passing over the electrode array is a typical sine wave, the amplitude of the waveform being governed by the size of the fish.

The counter processes the signal received from the electrodes and uses an algorithm, together with pre-set parameters, to assess whether the object is a fish or not. If the positive and negative parts of the waveform are similar the counter recognises the 'event' as a fish and logs it as either an 'upstream' or a 'downstream' fish. The counter also records information connected to the event such as date, time, direction, water conductivity and signal strength (deflection signal size). If the deflection signal does not conform to that of a 'typical fish', it is logged as an event or discarded. In this way the counter can distinguish between fish and inanimate objects such as leaves and twigs.

Appendix 2 - Species Apportionment and Data Analysis

Species apportionment is made on the basis of the deflection signal size that is generated by the counter when a fish passes over the electrodes on the weir. The validation study conducted by the Environment Agency (1997) using video equipment to identify and measure fish traversing the weir found a linear relationship between fish length and deflection signal size. The study concluded that a deflection signal size of 50 could be used to differentiate between the majority of salmon and sea trout between June and February (88% of all fish greater than 50 cm attained a deflection size greater than 50).

Data from previous years indicated that larger sea trout run into the river from March – May. In order to eliminate these larger sea trout from the salmon count within this period, the deflection signal size to differentiate salmon from sea trout is increased to 70. It must be stressed that this relationship is not 100% accurate and that some large sea trout, those greater than 70 cm, may be counted as salmon.

It is hoped that together with video, net catch and rod catch data that the ability of the counter to apportion species can be improved to get a more accurate split both between species and within species (refer to Appendix 4).

Appendix 3 - Video Validation / Audit Strategy and Methodology.

Video validation studies are carried out every 5-years, or during the commissioning of a new counter, and involve a detailed analysis of video and count data.

Data audits are carried out between validation studies to provide a 'snapshot' of the main fish runs and to highlight any errors in the counter data. Data audits aim to watch between 10-20% of the available video over a range of flow conditions.

Video Validation / Audit Strategy.

The following strategy is valid for both validation and auditing purposes.

Video footage of fish movements is collected over the fish pass between April and August. This is when the greatest numbers of fish and a wide range of river flows have been identified. The videotape is checked for quality before the operator leaves the site to ensure that any potential problems with picture quality or equipment failure are identified and rectified.

The aim is to carry out an initial review of the videotape within 7 days of collection. As each video is watched the "viewer" is required to complete a "video session recording sheet." This provides a record of each video session that the person has viewed and other relevant details e.g. picture quality, camera orientation etc.

The videos are reviewed twice. Initially the tapes are watched 'blind' i.e. without referring to the counter data. The tapes are then reviewed a second time, over the same period, using the data from the counter, to highlight fish that may have been missed during the first review. This ensures an unbiased video count and an accurate video record of fish passage.

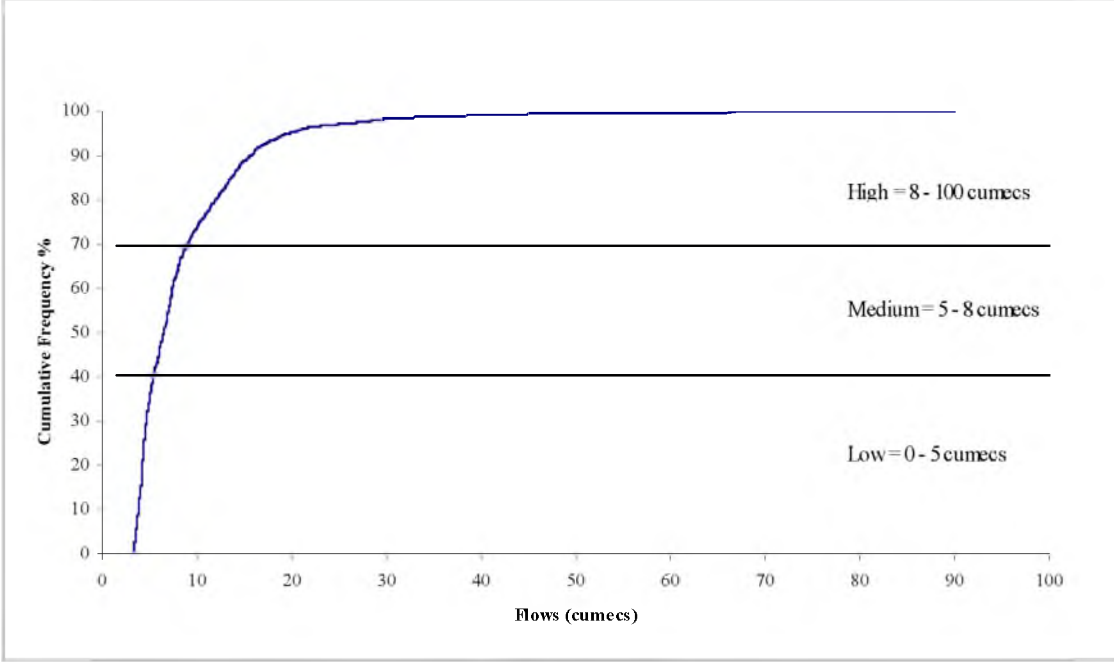
The protocols for data audits and validation are as follows:

Data Audits

Video footage over a range of flow conditions is selected to ensure that counter efficiencies do not significantly alter with changes in flow rate. If a problem is detected in the count data then further periods are analysed to identify and rectify the problem.

The flow ranges are selected by constructing a cumulative percentage frequency curve of all the flows available to fish over the period for which video is available (Figure A). Arbitrary cut-off points of 40% and 70% are then selected to separate the flows into high, medium and low flows. For the 2000 data the cut-off points between (1 May – 31 Aug) are <5 cumecs (low), 5 – 8 cumecs (medium) and >8 cumecs (high). Generally, most of the video footage selected for the audit covers periods of low and medium flows due to poor visibility conditions that exist during high flows, which make fish difficult to see on the video footage.

Figure A – Flows available for migratory fish at Gunnislake Weir over the period of available video - May to September 2000.



Video Validation

The watcher randomly selects, through the use of random number tables, two one-hour periods within each recorded video session. This acts as an initial screening of video data. Additional hourly periods may need to be reviewed to reach a required number of fish for statistical validity or because of poor picture quality etc.

Each period is viewed until an event i.e. fish, is seen. All events are identified. If it is a fish event then the fish is identified, where possible, and its total length and orientation (upstream/downstream) recorded.

- **Video Event Sample Size**

As large amounts of video data are collected, a meaningful method of quickly and accurately reviewing footage collected has been developed. This is based on an assumption of counter efficiency and a level of confidence required for statistical validity. Comparing the numbers of salmon and sea trout recorded by the counter with the numbers on the video footage, an estimate of counter efficiency can be made.

The following method is used as a guide to assess how many fish per sample group are required for an estimate of the counter detection efficiency at different levels of precision and confidence. A sample group could be defined as either upstream migrating salmonids or even a single species. The same criteria can be applied for different species, size classes or environmental conditions. The level of confidence for the purposes of counter validation should be between 90 - 95%.

As an example, assume that we were interested in assessing the detection efficiency of the counter for:

- Upstream migrating salmonids
- At a confidence level of 95%
- At a precision level of 5%

If we also assume a counter efficiency of 50%*, then reading the information from Table A, we can see that we would need to have seen and recorded 384 upstream salmonids on the videotapes over the year. This means that a sample size of 384 fish is required to ensure with 95% confidence that the estimated efficiency will be within ±5% of the true estimate - Environment Agency R&D Technical Report (1997).

**Based on the lowest efficiency that we could expect.*

Table A – Sample size required at various levels of confidence and precision, assuming a 50% counter efficiency.

	Confidence	90%	95%	99%
Precision	0.01	6765	9604	16590
	0.05	271	384	664
	0.1	67	96	166
	0.2	17	24	42

Table extract taken from Environment Agency R&D Technical Report (1997).

To reach the given sample size, two one-hour periods per 24-hour period are randomly selected. The periods are reviewed and the number of upstream migrating salmonids within each one-hour period recorded. If the required sample size is not reached then additional one-hour periods can be reviewed until the required sample size is reached. In practice, all of the video footage for the year is first reviewed using the above technique. If, at the end of the tape review, the sample size for the whole year is below the required sample size or level of confidence/precision, then the tapes are reviewed again. This time, only one hour per day would be randomly selected until the required sample size is reached. Alternatively, a lower level of confidence, requiring a smaller sample size, could be selected.

- **Matching Counter Data and Video Events**

To determine the efficiency of the:

i. Counter
ii. Video watching

During the second videotape review, the counter data is utilised to identify events that have been detected or missed by the counter. The video data is then matched to the corresponding counter data and recorded as one of the following:

- Upstream Fish - Salmon, Sea Trout or other species.
- Downstream Fish - Salmon, Sea Trout or other species.
- Upstream Event
- Downstream Event

Appendix 4 – The use of historical net, rod and trapping data for species apportionment at Gunnislake fish pass on the River Tamar.

In river systems where salmon and sea trout comprise the migratory stock it is important that any fish counter data can be accurately split into the major run components i.e. salmon and sea trout. To provide this information the run timing and size structure of the stock must be known. It is also vital that the relationship between fish length and deflection size is quantified.

This short report explores the predictive capacity of the fish counter at Gunnislake with regards to its ability to discriminate between salmon and sea trout. The analysis uses the relationship between signal size and fish length, together with a description of the migratory salmonid population from historical trap, rod and net catch data.

The size structure of salmon and migratory trout populations on the River Tamar.

Information on the size structure and/or run timing on the River Tamar can be obtained from three sources:

(i) Historical rod returns

Figure 1 - Salmon and sea trout length frequency histogram obtained from historical rod returns (1990 to 1999 inclusive.).

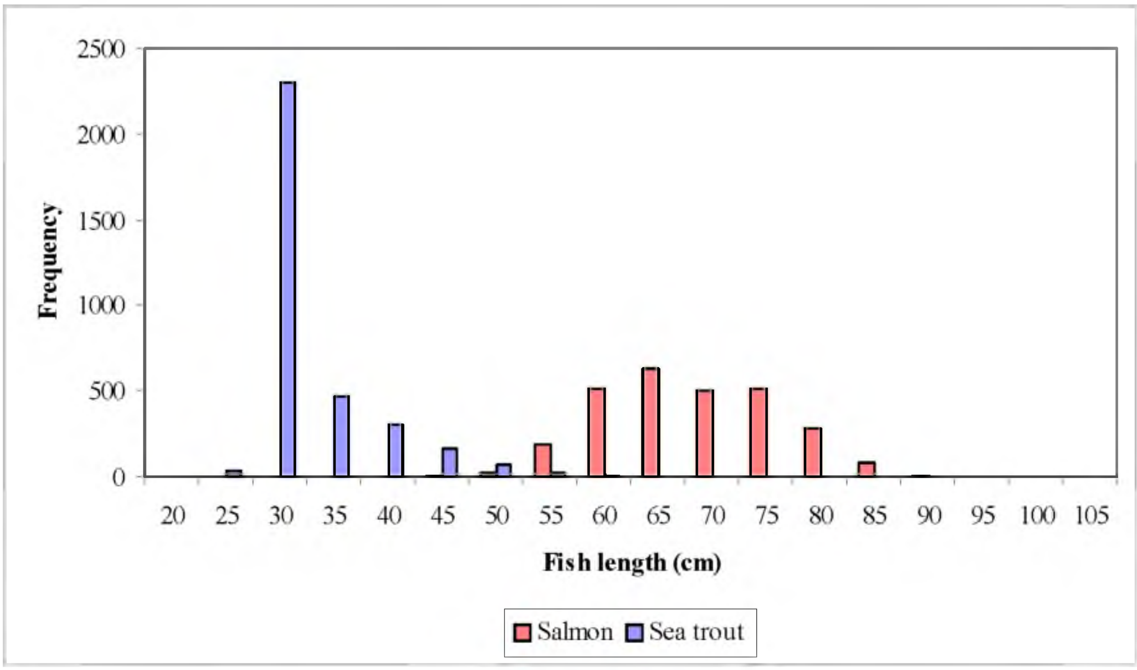


Figure 1 shows a small degree of overlap between the largest sea trout and the smallest salmon. However, only a relatively small number of sea trout were recorded with lengths greater than 50cm and the same is true for salmon having lengths of less than 50cm.

(ii) Historical net returns

Figure 2 - Salmon and sea trout length frequency histogram obtained from historical net returns (1990 to 1999 inclusive).

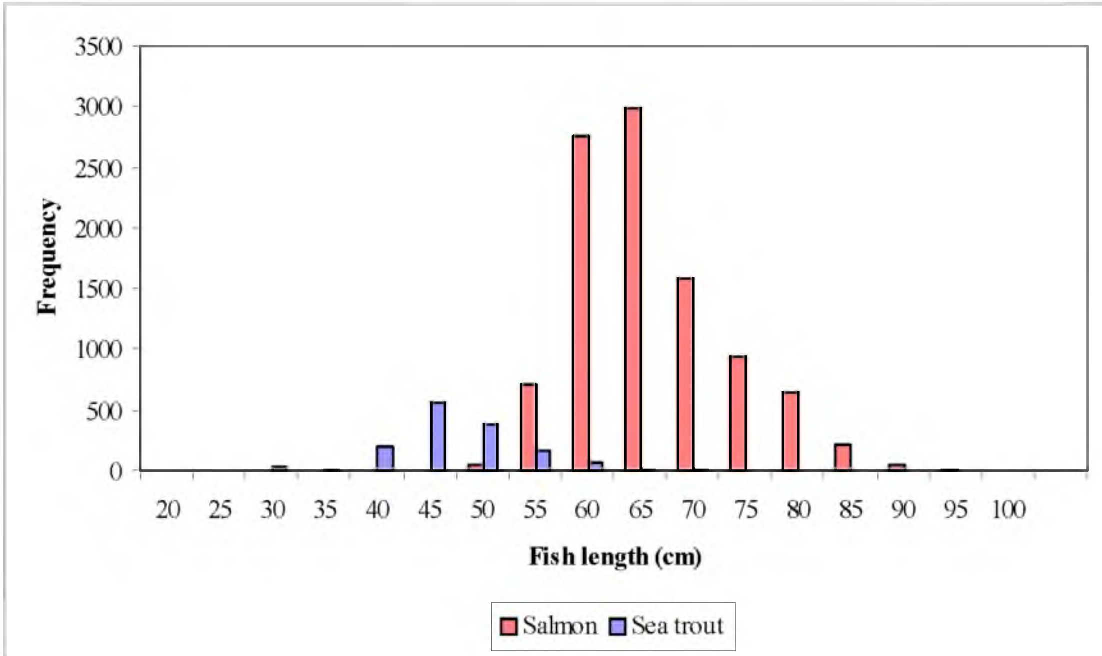


Figure 2 also shows some overlap between the largest sea trout and the smallest salmon but to a smaller degree than that seen in the rod catches. Again the degree of overlap is small with only a relatively small number of sea trout being recorded with a lengths greater than 50cm. The same is true for salmon with lengths less than 50cm. The increase in the degree of overlap is probably due to an increase in the numbers of large sea trout recorded by the nets relative to the rods. Anecdotal evidence suggests that large repeat spawning sea trout are harder to catch on rod and line possibly explaining an underestimation of their numbers in the rod catch data. The lower numbers of small sea trout, in comparison to the rod catch data, can be explained by the sampling bias associated with the mesh sizes of the nets that are used in the estuary.

(iii) Historical trap data

Figure 3 - Salmon and sea trout length frequency histogram obtained from historical trap data (1986 to 1988 inclusive).

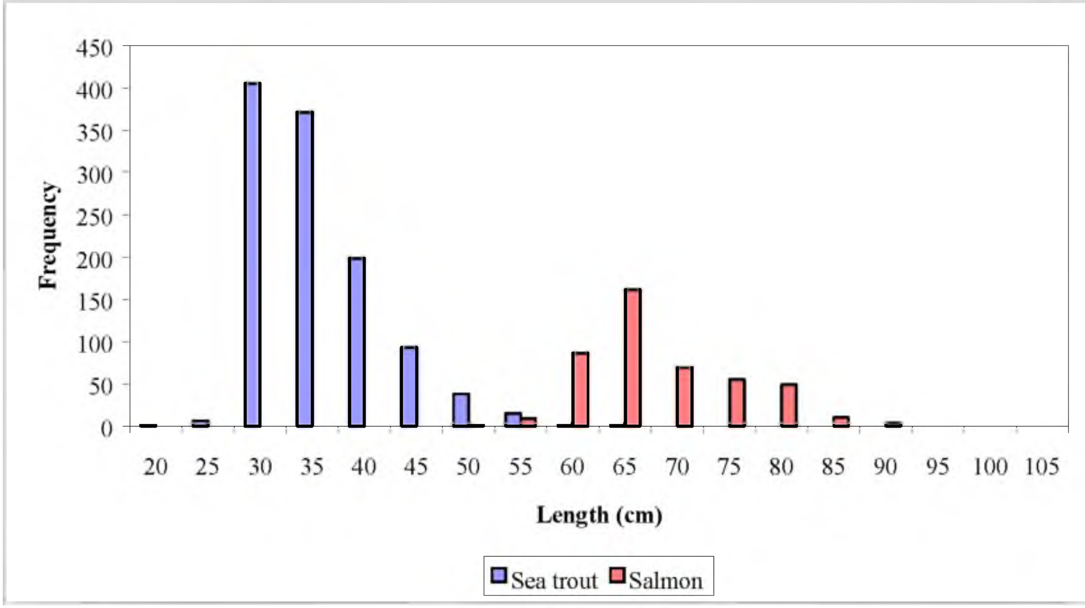


Figure 3 again shows some overlap between the largest sea trout and the smallest salmon. In comparison to the rod and net catch data the overlap shown by the trap data occurs at a slightly greater size. Only a relatively small number of sea trout were recorded with lengths greater than 55cm and salmon with lengths less than 55cm. This shift in the position of the overlap is due mainly to a proportional decrease in the numbers of small salmon recorded in the trap data and could possibly be explained by a change in the size structure of the salmon population between the 80's and the 90's.

The length frequency distribution histograms from all three sources suggest that there is a sufficient difference in the length of salmon and migratory trout on the River Tamar for fish length to be used to separate the two species.

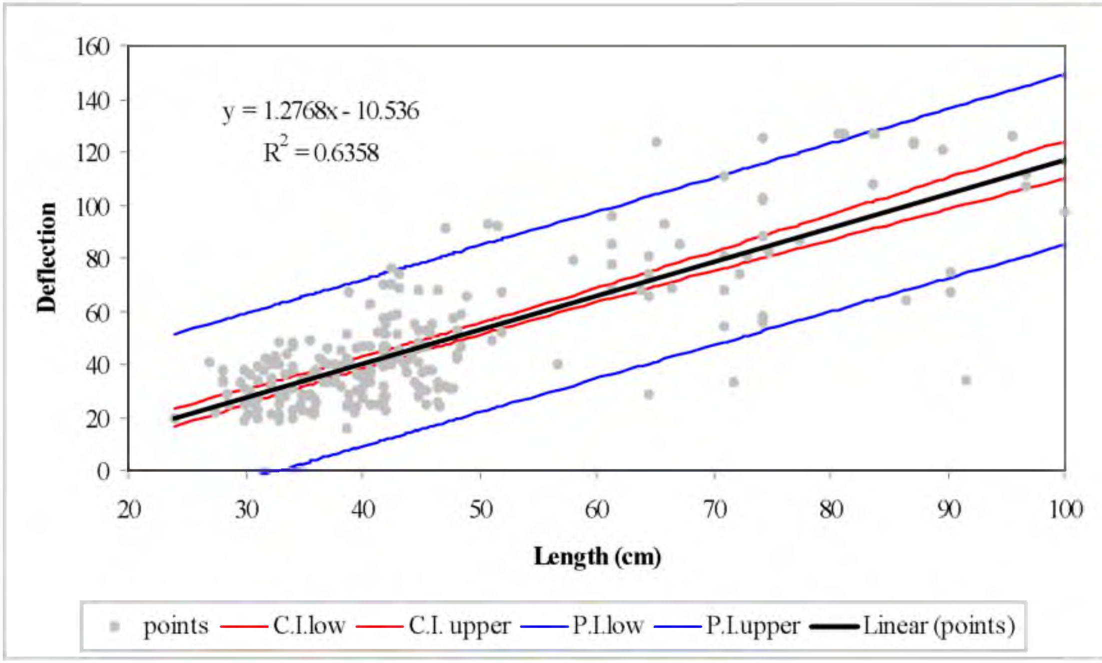
The relationship between fish length and deflection size.

Several studies have shown that the magnitude of the electrical disturbance created by a fish as it passes over a resistivity counter is dependent on its size (Dunkley & Shearer, 1982; Fewings, 1987; Jones & Strange, 1989). The ability of the Logie 2100a fish counter at Gunnislake to size fish was investigated by comparing signal size to fish length. Fish lengths were obtained from downward looking video footage recorded in the fish pass at Gunnislake and were matched to the associated counter data.

The sizing capability of the Logie 2100a fish counter at Gunnislake on the River Tamar is shown in Figure 4.

Figure 4 - Gunnislake Weir fish counter - the relationship between deflection size and fish length.

(The regression line; upper and lower prediction intervals and confidence intervals are shown.)



The relationship between deflection size and fish length can be explained by a linear regression. For the upstream migrants, fish length accounted for 64% of the variability in signal size. Previous studies on the relationship between signal size and fish length at Gunnislake and on other rivers have found a similar relationship (Nicholson, 1997). The inclusion of conductivity, water depth and temperature in multiple regression analysis may improve the relationship and is under consideration for future studies.

It is interesting to note that two clusters of fish are clearly evident: the smaller being migratory trout and the larger salmon. The different populations would probably not be so evident in rivers where the overlap between these two species was not so distinct i.e. where there is a large size overlap between the two species.

Conclusions

All the evidence indicates that salmon and sea trout in the River Tamar fall into two distinct size populations and that the fish counter at Gunnislake is, under normal conditions, very good at apportioning species. The analysis of the net, trap and rod catch data also supports the use of the deflection cut-off points currently used to apportion species.

It is hoped that future use of trap, rod and net catch data, together with video evidence, will enable us to further increase the efficiency of the fish counter at Gunnislake. This data together with fish counter and other fishery survey data will also provide a more detailed picture of both migratory and non-migratory fish populations in the River Tamar catchment. This is essential for the development of improved fishery management plans and the protection of rare or endangered species.

References

Dunkley, D.A. & Shearer, W.M. (1982). An assessment of the efficiency of a resistivity fish counter. *Journal of Fish Biology* **20**: 717-737.

Fewings, G.A. (1987). The validation of two resistivity counters using infra-red telesurveillance at two sites in the North West of England. Unpublished MSc Thesis, University College of North Wales, Bangor, Wales.

Jones, G. O. & Strange, C. D (1989). Evaluation of the North of Scotland Hydro-Electric Board Mark X fish counter sited at Trostrey weir, River Usk, Wales. NRA (Welsh) Report No. *PL/EAE/89/1.* 24 pp.

Appendix 5 – Table B: Fish deflection values for upstream migrating salmonids recorded at Gunnislake Weir in 2000.

Deflection	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0				0	0	0	0	0	0	0		
5				0	0	0	0	0	0	0		
10				0	0	0	0	0	0	0		
15				0	0	0	0	0	0	0		
20				8	11	87	220	14	3	13		
25				26	56	365	643	73	26	37		
30				37	134	457	571	55	31	47		
35				46	125	392	417	42	25	49		
40				26	109	326	329	52	27	55		
45				25	128	203	217	43	28	44		
50				27	103	157	161	63	28	39		
55				13	78	106	108	57	29	22		
60				23	49	95	97	66	17	21		
65				17	66	52	94	78	17	16		
70				8	54	52	95	57	15	14		
75				10	46	36	73	76	12	12		
80				5	36	27	53	77	16	7		
85				13	23	16	51	59	7	6		
90				13	17	7	49	53	9	6		
95				9	19	14	43	55	3	7		
100				4	7	4	22	39	6	5		
105				5	11	16	24	18	4	5		
110				3	6	6	21	19	3	2		
115				3	8	7	13	17	3	6		
120				1	7	2	14	10	2	2		
125				5	31	16	26	22	3	5		
130				1	0	17	14	11	5	2		

Appendix 6 - Daily Movements of Salmon and Sea Trout Recorded at Gunnislake Fish Counter in 2000.